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Rheological and Sensory Properties of Sodium Reduced Ezogelin Soup with Potassium Chloride and L-Glutamic Acid

Potasyum Klorür ve L-Glutamik Asit Kullanılarak Sodyum Seviyesi Azaltılmış Ezogelin Çorbasının Reolojik ve Duyusal Özellikleri

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Abstract

Objective: Today, the amount of salt that has been consumed by people is much higher than the value recommended by the World Health Organization (WHO). Excess sodium intake may cause many ailments, especially hypertension and cardiovascular diseases. Therefore, it is encouraged to perform salt formulation studies to reduce the sodium level of processed foods that lead to excessive sodium intake. In this study, rheological and sensory properties of ezogelin soup made using salt formulation containing NaCl, KCl and L-glutamic acid were investigated.

Materials and Methods: The rheological properties of soups were measured using a rheometer. Flavor profile method was used to describe and quantify sensory characteristics of soup samples.

Results: The rheological properties of ezogelin soups with different salt replacer formulations were analysed at a wide range of temperatures (25, 35, 45, 55 and 65°C). All ezogelin soups behaved as shear thinning (n<1) and exhibited entagled solution properties. The power law model was determined to be adequate (r^2=0,937–0,998) to fit the flow curves of ezogelin soups. The viscosity of all soup samples showed a strong dependence on temperature and temperature dependency of rheological parameters followed the Arrhenius model (r^2=0,931–0,987). The activation energy (Ea) values of ezogelin soups were found between 14,350 and 28,284 J/mol. Sensory analysis showed that 50% KCl addition increased bitterness and decreased saltiness of the soup. The salt formulation (50% NaCl, 40% KCl and 10% L-glutamic acid) seemed to be an ideal formulation to attain 50% sodium reduction in ezogelin soup without negatively affecting its palatability. Additionally, it was seen that L-glutamic acid addition caused a decrease in the pH of the ezogelin soup.

Conclusion: Salt formulation containing 50% NaCI, 40% KCI and 10% L-glutamic acid could be used for 50% NaCI reduction in ezogelin soup.

Keywords: Sodium Reduction, Viscosity, Rheological Property, Sensory Analysis, Ezogelin Soup

Özet

Amaç: Günümüzde insanların tuz tüketim miktarı Dünya Sağlık Örgütü'nün önerdiği değerin çok üzerindedir. Fazla sodyum alımı başta hipertansiyon ve kalp-damar hastalıkları olmak üzere birçok rahatsızlığa neden olabilmektedir. Dolayısıyla, aşırı sodyum alımına neden olan işlenmiş gıdaların sodyum seviyesini azaltmak için tuz formülasyonu çalışmalarının yapılması teşvik edilmektedir. Bu çalışmada, NaCI, KCl ve L-glutamik asit içeren tuz formülasyonunu ezogelin çorbasında kullanmanın ürünün reolojik ve duyusal özellikleri üzerine etkisi incelenmiştir.

Materyal ve Yöntem: Çorbaların reolojik özellikleri reometre kullanılarak ölçülmüştür. Çorba örneklerinin duyusal özelliklerini tanımlamak ve ölçmek için lezzet profili yöntemi kullanılmıştır.

Bulgular: Bu çalışmada, farklı tuz ikame formülasyonları içeren ezogelin çorbalarının reolojik özellikleri geniş bir sıcaklık aralığında (25, 35, 45, 55 ve 65°C) analiz edilmiştir. Bütün ezogelin çorbalarının, kayma ile incelen (n<1) davranış sergilediği ve karışık (entagled) çözelti özellikleri sergilediği görülmüştür. Power-law modelinin ezogelin çorbalarının akış eğrilerine uygun olduğu tespit edilmiştir (r^2=0,937-0,998). Tüm çorba örneklerinin viskozitesinin sıcaklığa kuvvetli bir şekilde bağlı olduğu görümüştür ve sıcaklık ile reolojik parametrelerin ilişkisi Arrhenius modelini takip etmiştir (r^2=0,931-0,987). Ezogelin çorbalarının aktivasyon enerjisi (Ea) değerlerinin 14,350 ve 28,284 J/mol arasında değiştiği bulunmuştur. Duyusal analiz, %50 KCl ilavesinin çorbanın acılığını artırırken tuzluluğunu azalttığını göstermiştir. %50 NaCl, %40 KCl ve %10 L-glutamik asit içeren tuz formülasyonu, ezogelin çorbasının lezzetini olumsuz yönde etkilemeden %50 sodyum azaltımı elde etmek için ideal bir formülasyon gibi görünmektedir. Ayrıca, L-glutamik asit ilavesinin ezogelin çorbasının pH değerinde bir azalmaya neden olduğu görülmüştür.

Sonuç: %50 NaCl, %40 KCl ve %10 L-glutamik asit içeren tuz formülasyonunun ezogelin çorbasının NaCl seviyesini %50 oranında azaltmak için kullanılabileceği görülmüştür.

Anahtar Kelimeler: Sodyum Azaltımı, Vizkosite, Reolojik Özellikler, Duyusal Analiz, Ezogelin Çorbası

1.Introduction

Ezogelin, is one of the most consumed soup varieties of Turkey, is made with some main ingredients like red lentils, bulgur, rice and spices (Ibanoglu ve Ibanoglu 1998, Egresi 2016). This slightly spicy lentil soup a good source of fiber and protein can be eaten at any meal (Anonymous 2012). Ezogelin soup consumed in Turkey can be home-made or instant. However, it has been reported that commercial instant soups have gained popularity in recent years due to changing consumer preference and lifestyle (Niththiya et al. 2014). Although prepared soups have several advantages over homemade soups, their high sodium (salt) content may create some health problems such as heart failure, hypertension, stroke, kidney problems, stomach cancer and osteoporosis (Anonymous 2018). A study conducted by Erdem et al. (2010) showed that daily salt intake of the Turkish population (18,01 g/day) is nearly three times higher than the level recommended by the World Health Organization (WHO) (Anonymous 2007). Accordingly, hypertension and chronic kidney diseases have become the majör public health problems in Turkey (Sengul et al. 2013).

Different strategies have been implemented to reduce salt consumption of populations i.e. gradual NaCl reduction, use of salt replacers or consumer education (Webster et al. 2011). It is known that most of the salt consumed by people comes from processed foods. Thus, planning a salt reduction strategy by considering these foods is highly acceptable. Foods that are high in sodium include: processed meats, some canned foods, cheeses, pickles and soup-base products (Jacobson et al. 2013, Mueller et al. 2016).

The use of salt substitutes is probably the most widely used method to decrease salt content in processed foods, in particular, KCl (Desmond 2007). This is due to that physical properties of KCl have shown similarity with NaCl and it emerges as an alternative solution to common potassium deficiency problem (Cordain et al. 2005, Anonymous 2009, Yang et al. 2011). Nonetheless, owing to the higher molecular weight of cations (K+), KCl may impart undesirable side tastes such as bitterness, metallic and acrid to foods when the large amount is applied (Waimaleongora-Ek 2002, Sinopoli and Lawless 2012). Cepanec et al. (2017) reported that L-glutamic acid is one of the most successful taste improving agent which may eliminate or reduce KCl-originated unpleasant off-tastes. In addition, the enrichment of foods with nutritionally acceptable amino acids is beneficial for improving the nutritional status of persons (Chopra 1974). On the other hand, variation in ingredients or their concentration levels may impact quality properties of foods. Especially, rheological properties of fluid foods could be affected by their composition. Many of the sensory properties of food are directly related to its rheological property (Yılmaz et al. 2010, Gao et al. 2011).

Soups contain many varied ingredients and they are in the form of dispersions (Ahmed et al. 2016). Many studies have demonstrated that NaCl may significantly influence the rheological behaviour of products since it is often subject to interactions with the other ingredients (Ainsworth and Plunkett 2007). Subsequently, the salt addition resulted in a linear increase in the viscosity of liquid products (Pham 2013). The viscosity varies more markedly than the other thermo-physical properties for most liquid products. Soups generally consumed at high temperatures (60°C or above). It is known that the serving temperature of soup both affects the saltiness perception and its viscosity (Ibanoglu and Ibanoglu 1998, Kim et al. 2015). The relation between shear rate and viscosity can be considered to categorize food products into Newtonian or non-Newtonian, which would serve useful information for structural analysis, process design and quality control (Rao and Ananthswaran 1982).

In literature, there are some studies conducted to reduce sodium content of soup products (Roininen et al. 1996, Kremer et al. 2009, Gonçalves et al. 2014, Leong et al. 2016). Nevertheless, no study was conducted related to salt reduction in traditional Turkish soups. Rheological properties of ezogelin soup was studied by Ibanoglu and Ibanoglu (1998) at different temperatures (15-70°C). However, they performed their study by using a Brookfield viscometer and did not add any additional ingredient apart from common recipe. The aim of this study is to reduce sodium content of traditional Turkish Ezogelin soup by using KCl and L-glutamic acid without negatively affecting its some selected quality properties. In this study, the mixture containing different percentages of KCl (25-50%) and L-glutamic acid (10-25%) was used to replace 50% of NaCl in ezogelin soup. The quality control parameters (sensory and rheological properties, pH) were tested to evaluate the feasibility of using this salt substitute to develop low salt ezogelin soup

2.Material and Methods

2.1.Materials

The ingredients (red lentil (Duru, Turkey), bulgur (Duru, Turkey), rice (Duru, Turkey), unsalted butter (Lurpak, Turkey), sunflower oil (Yudum, Turkey), wheat flour (Soke, Turkey), unsalted tomato paste (Tamek, Turkey), onion, dried red pepper and mint (Bagdat, Turkey)) used in ezogelin soup preparation were purchased from the local market in Izmir, Turkey. L-glutamic acid (Sigma, Germany), NaCI (Merck, Germany), KCI (Merck, Germany) and taste references (sucrose (Merck, Germany), citric acid monohydrate (Merck, Germany), caffeine (Sigma, Germany), tannic acid (Merck, Germany) and monosodium glutamate (MSG) (Merck, Germany) were from ISOLAB (Izmir, Turkey).

2.2 Preparation of Ezogelin Soups

According to the research carried out by Anonymous (2010), there were large variations in the salt content of ready to eat soups, changing between 0,15 to 1,00 g per 100 g. When the salt level of the ezogelin soups sold in Turkish market are examined, it is found that the salt level roughly ranges between 0,50-1,25 g for 100 g soup (Anonymous 2019). Then, the amount of salt that was added in soup was determined by averaging these values. Also, there are some studies in the literature which used the same concentration (0,90 g/100 g) (Anonymous 2001; Mitchell et al. 2011). By considering this salt ratio, five different salt formulations were used to prepare ezogelin soups: ezogelin with 100% NaCI (A), ezogelin soup with 50% NaCI and 50% KCI (B), ezogelin soup with 50% NaCI, 40% KCI and 10% L-glutamic acid (C), ezogelin soup with 50% NaCI, 35% KCI and 15% L-glutamic acid (D), ezogelin soup with 50% NaCI, 25% KCI and 25% L-glutamic acid (E). These ratios were determined after trials.

To prepare ezogelin soup, the sunflower oil (24 g) were heated in a cooking pot and small chopped onions (75 g) were added and fried. Then, washed red lentil (190 g), rice (18 g) and bulgur (18 g) was added and boiling water (1000 ml) was poured and whisked to keep smooth. It was simmered for about 30 minutes until allingredients were well softened. Oil (18 g) was heated in a separate pan and then wheat flour and tomato paste wereadded and fried. After then, this mixture was added to the cooking pot and extra water (600 ml), red pepper (1 g), mint (0,5 g), NaCI, KCI and/or L-glutamic acid were added according to formulations given above. The mixture was pureed in a blender (Braun, Istanbul, Turkey) at the highest speed for 2 minutes. The recipe for soup was taken from an unpublished survey of homemade ezogelin soup.

2.3.Determination of pH Values of the Test Samples

The pH values of the samples were measured by Anonymous (2000). These values were determined at 25°C using a pH meter (AquaLab LITE).

2.4.Rheological Measurements

The rheological properties were measured using a rheometer (MCT 302, Anton Paar, GmbH, Germany) in the system of concentric cylinder (diameter 27 mm) at temperatures of 25, 35, 45, 55 and 65°C for shear rate range of 0,1–100 s-1. These temperature range was selected by considering serving and room temperatures. The graph (shear stress versus shear rate) is plotted on a log-log scale and data were fitted to the power law model (Equation 1). Values of consistency coefficient (k) and flow behavior index (n) were found by studying the flow behavior of the ezogelin soups. Its viscosity (η) is reported as a function of shear rate (Equation 1a) (Steffe 1996).

$$\sigma=k(\ddot{y})n \qquad Eq(1)$$

$$\eta=k(\ddot{y})n-1 \qquad Eq(1a)$$

where, σ is the shear stress (Pa), k is the consistency coefficient, ÿ is the shear rate (s-1), and n is the flow behavior index.

2.5.Modeling the Effect of Temperature on the Ezogelin Flow Behavior

The variation of k as a function temperature was modeled using the Arrhenius model in Eq (2) (Augusto et al. 2012, Abdullah et al. 2018).

$$k=k0 \exp (Ea/RT) \quad Eq(2)$$

where k0=an apparent viscosity index at a reference temperature (T=∞), Ea=activation energy, R=universal gas constant (8,314 J/mol.K), and T=absolute temperature

2.6.Oscillatory measurement analysis

The dynamic rheological experiment (oscillatory test) can be used to determine viscoelastic properties of food. The storage (or elastic) modulus G′ expresses the magnitude of the energy that is stored in the material or that is recoverable per cycle of deformation. The loss (or viscous) modulus G″ is a measure of the energy that is lost as viscous dissipation per cycle of deformation (Gao et al. 2011). The frequency sweep test was employed over the range of 0,01 to 100 Hz and Anton Paar Rheometer Data Analysis software was used to obtain the experimental data and to calculate G′ and G″. The rheological measurements were performed in duplicate.

2.7.Sensory methods

Flavor profile method (Anonymous 1985) was used to describe and quantify sensory characteristics of the test samples. The sensory panel consisting of 8 members (4 males and 4 females) in the age range of 30 to 40 from Central Research Institute of Food and Feed Control (Bursa, Turkey) was formed and trained. They were chosen on the basis of their ability, sensory analysis experience and availability to participate in testing sessions. A trained sensory panel developed a consensus vocabulary of 6 attributes (saltiness, bitterness, umami, sourness, sweetness and astringency (mouth drying)) over 3 tasting sessions. During panel training, the taste standards were served to the assessors to provide reference points for taste intensity ratings. Approximately 30 mL of ezogelin soup at about 60°C were presented monadically in a balanced order with three digit random codes in paper containers and they were asked to rinse their palates between samples with water (Pınar, Turkey). Evaluation of each term was performed individually using 10 cm unstructured line scales (scaled 0–100) (Carlucci and Monteleone 2001). The panel was performed in partitioned boots equipped with daylight.

2.8.Statistical Analyses

Data were analyzed using SPSS 21 (IBM SPSS Statistics 21). Duncan's Multiple Range Test was used for mean separation for all data at the 5% significance level.

3.Results and Discussion

3.1.pH Values of the Test Samples

The pH values of 5 ezogelin soups were determined (Table 1). It was seen that the L-glutamic acid addition slightly decreased the pH values of the samples, which is related to acidic characteristic of L-glutamic acid (Ophardt 2003). Thus, the impact of L-glutamic acid addition on soup pH should be considered while deciding the ideal salt formulation. On the other hand, addition of 50% KCl (formulation B) to the ezogelin soup had no significant effect on the pH. This is because univalent salts (NaCI or KCI) have a similar impact on the pH of food (Ichikawa and Shimomura 2007).

Table 1. pH values of ezogelin soups*

Formulation	pH
A	6,55±0,03[a]
B	6,60±0,02[a]
C	6,02±0,02[b]
D	5,76±0,01[c]
E	5,40±0,01[d]

**Values are mean±standard deviation (n=3). Different letters in a column indicate statistically significant differences by Duncan's multiple range test (P < 0,05).*

3.2.Rheological Behavior of Ezogelin Soup

Rheological properties of ezogelin soups were investigated at temperature range between 25-65°C. Figure 1 shows the flow behavior characteristic of ezogelin soup with 10% L-glutamic acid at varying temperatures. Similar flow curves were also obtained for the other formulations.

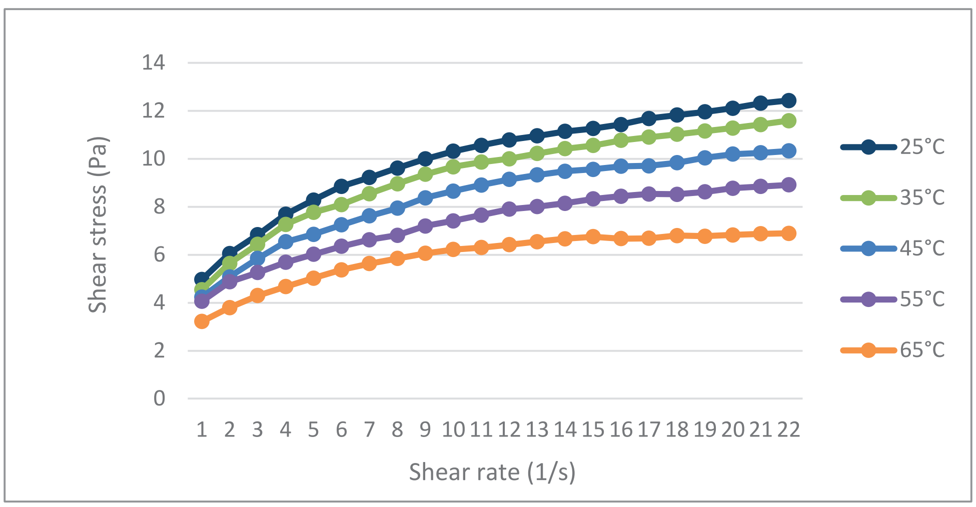

Figure 1. Flow curves of ezogelin soups containing 10% glutamic acid at different temperatures (25°C, 35°C, 45°C, 55°C and 65°C).

Figure 1 revealed that there was a non-linear relation between shear stress and shear rate, indicating that ezogelin soups with different salt formulations had non-Newtonian properties. The experimental results were well fitted to the simple power law shear stress and shear rate of model (Eq.1) with high determination coefficients (r^2 =0,942~0,998) (Table 2). These results are supporting the fact that power law is the most extensively used model to describe the rheological behavior of food (Gratao et al. 2007). The degree of pseudoplasticity can be determined by the flow behavior index (n) as n increases, pseudoplasticity decreases (Grigelmo et al. 1999). Results showed that all ezogelin soups containing different salt replacers had high pseudoplactic (shear-thinning) behaviors with n values (0,185~0,377). Similar observations were made by Erbas et al. (2005), Celik et al. (2010), Yılmaz et al. (2010) and Koca et al. (2015).

The consistency coefficient, k, ranged from 1,644 and 8,913 Pa.sn. k value gives an idea of the viscosity of the fluid and a high k value indicates a high viscosity (Björn et al. 2012). Table 2 shows that k decreased with increasing temperature from 25 to 65°C. Similar observations were reported by Heikal and Chhinnan (1990), Sopade et al. (1993), Maskan and Göğüş (2000). On the other hand, k changed with salt formulation but a consistent trend was not observed. Moreover, n values are nearly independent of the salt formulation and temperature, which was in accord with the findings by Hassan and Hobani (1998), Yılmaz et al. (2010) and Adebowale and Sanni. (2013).

Table 2. Flow properties of ezogelin soups prepared with varying salt replacers at temperatures of 25 to 65°C.

Formulation	T (°C)	*k* ($Pa.s^n$)	*n*	r^2	k_0 ($Pa.s^n$)	Ea (J/mol)	r^2
A	25	4,335±0,01	0,204±0,01	0,963	0,013	14350	0,987
	35	3,673±0,02	0,264±0,02	0,985			
	45	2,951±0,03	0,287±0,02	0,982			
	55	2,449±0,03	0,340±0,03	0,990			
	65	2,259±0,02	0,355±0,02	0,989			
B	25	4,656±0,02	0,257±0,02	0,998	0,001	21217	0,943
	35	2,780±0,01	0,300±0,03	0,994			
	45	2,460±0,02	0,317±0,01	0,992			
	55	1,803±0,03	0,344±0,02	0,991			
	65	1,644±0,03	0,350±0,03	0,998			
C	25	5,689±0,02	0,234±0,01	0,970	0,015	14400	0,947
	35	4,831±0,03	0,273±0,02	0,981			
	45	4,416±0,03	0,271±0,02	0,995			
	55	3,614±0,02	0,299±0,03	0,983			
	65	2,698±0,01	0,329±0,01	0,942			
D	25	8,166±0,02	0,185±0,01	0,937	0,005	18199	0,937
	35	5,129±0,02	0,263±0,01	0,995			
	45	4,365±0,03	0,257±0,03	0,997			
	55	3,802±0,03	0,309±0,02	0,994			
	65	3,228±0,01	0,321±0,02	0,991			
E	25	8,913±0,02	0,290±0,01	0,991	0,0001	28284	0,931
	35	4,395±0,03	0,277±0,02	0,983			
	45	3,192±0,01	0,307±0,01	0,993			
	55	2,761±0,01	0,294±0,01	0,994			
	65	2,109±0,02	0,377±0,02	0,993			

3.2.1.Effect of Temperature

Figure 2 shows that apparent viscosity decreases with rising temperature. As temperature ascends, intermolecular (cohesive) forces between the molecules decrease, which leads to molecular distance and flow becomes freer. Consequently, viscosities of fluids drop (Sahin and Sumnu 2006). Similar trends were obtained for ezogelin soups made with other salt formulations. It was seen that the temperature dependence of the consistency index (average viscosity of the fluid) (k) obeyed the Arrhenius law Eq (2) (r^2=0,931-0,987).

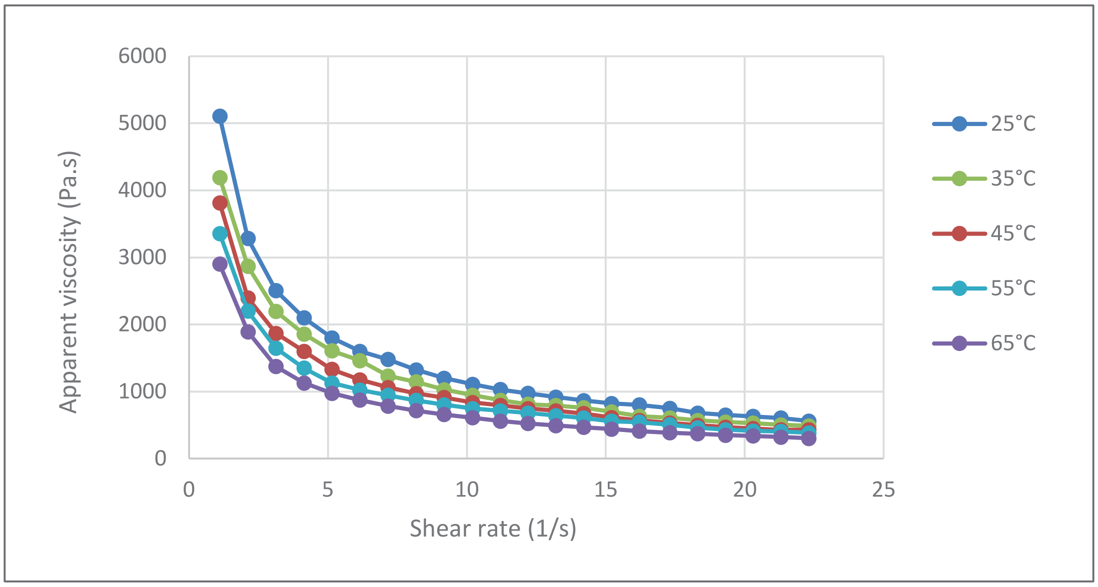

Figure 2. Effect of shear rate on the apparent viscosity of ezogelin soup with formulation C.

Log-log plot of the equation was formed in order to calculate the parameters of relation. The slope of the Arrhenius plot was used to find the activation energy (Ea). It reflects the sensitivity of viscosity to temperature changes; higher Ea means that the viscosity is relatively more sensitive to a temperature change (Holdsworth 1971, Sopade and Filibus 1995, Ibanoglu and Ibanoglu 1998). The Ea values of ezogelin soups were varying between 14350 and 28284 J/mol. The results indicated that the activation energy soared with increasing L-glutamic acid concentration. Ezogelin soup with salt formulation (E) had the highest Ea. The same trend was reported in the enriched tarhana soup and beetroot juice (Yılmaz et al. 2010, Juszczak et al. 2010).

3.3.Dynamic measurement analysis

The present study showed that the all ezogelin soup samples exhibited “entagled solution” properties (G''>G' at low frequencies and G'>G'' at high frequencies). In fact, very few material (guar solution, thick starch soup) exhibit this behaviour (Ahmed et al. 2016). This thickness is related to the starch that comes from the main ingredient like lentin, wheat, bulgur and rice (Dewan 2013). With increase in ω, both G'' and G' increased which is in agreement with Nayik et al. (2018). It was also observed that when the temperature was increased, both G’ and G'' decreased. This result is in line with the studies by (Hundal and Takhar 2009; Nayik et al. 2018). However, it was seen that salt replacement does not affect mentioned parameters (G', G'') consistently.

3.4.Sensory properties of ezogelin soups

Sensory evaluation of the samples is given in Table 3. The sensory panel found that perceived salty, bitter, sour, umami and sweet tastes differed significantly among the evaluated samples (P<0,05) and use of different salt mixtures showed no statistically significant effect on astringent taste (P>0,05).

Table 3. Sensory properties of ezogelin soups*

Formulations	Saltiness	Bitterness	Astringent	Sweetness	Sourness	Umami
A	56,38±1,62[a]	14,75±0,75[a]	11,38±0,60[a]	10,13±0,72[b]	11,0±0,71[b]	12,75±0,65[b]
B	25,38±1,27[b]	28,88±1,03[c]	13,50±1,20[a]	6,25±0,45[a]	7,38±0,46[a]	6,63±0,38[a]
C	52,63±1,32[a]	16,13±0,85[ab]	12,13±0,44[a]	11,00±0,46[b]	13,13±0,77[b]	14,00±0,76[b]
D	25,25±1,37[b]	16,38±0,92[b]	11,25±0,59[a]	10,63±0,78[b]	27,25±0,92[c]	16,63±0,50[c]
E	18,00±1,00[c]	14,13±0,74[a]	12,00±0,76[a]	7,00±0,57[a]	37,38±0,84[d]	20,00±0,65[d]

Values are mean±standard deviation (n=3). Different letters in a column indicate statistically significant differences by Duncan's multiple range test (P < 0,05).

The results show that ezogelin soup with salt formulation C can be an appropriate formulation for 50% NaCI replacement (Figure 3). It reached the same level in saltiness with the reference, whereas differences in saltiness were detected among the reference and other soup formulations. The soup with salt formulation B was found more bitter and sour but less salty, sweet and umami than the control (P<0,05). Actually, bitterness is a common problem with the use of KCl depending on the level of substitution, as observed in various sodium reduction studies (Katsiari et al. 1997; Horita et al. 2011). It was observed that salty and umami taste perception increased but bitter taste decreased with 10% L-glutamic acid addition. Sourness of the soup soared in parelel with L-glutamic acid incorporation. The soup with salt formulation E was found the most sour (P<0,05). It could happen as humans perceive the taste of L-glutamic acid and its salts as umami, but depending on its chemical form, L-glutamate may also have other taste components; for instance, salty (for monosodium L-glutamate), bitter (for monoammonium L-glutamate) or sour (for free L-glutamic acid) (Bachmanov et al. 2016).

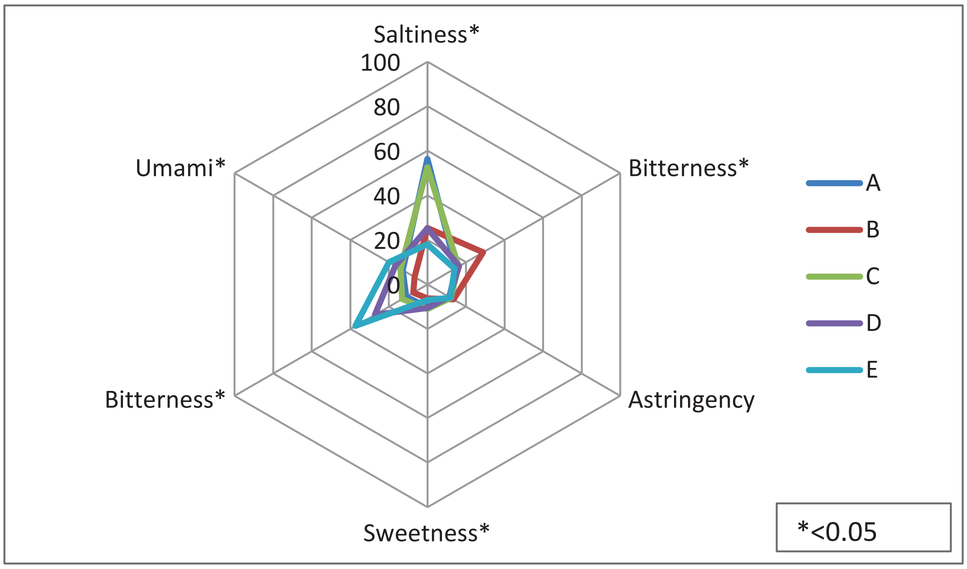

Figure 3. Star diagram of sensory evaluation

4.Conclusion

The salt formulation C (50% NaCI, 40% KCI and 10% L-glutamic acid) seemed to be an ideal formulation to attain 50% sodium reduction in ezogelin soup without negatively affecting its palatability and rheological properties, although it led to a bit decreasement in pH value. These results can be helpful in process design and quality control of sodium-reduced ezogelin soup for producing a healthier soup product without affecting consumer acceptance negatively. Importantly, our results provide evidence for L-glutamic acid that can be used in soups for sodium reduction. Further studies should
in soups for sodium reduction. Further studies should
investigate the effect of using different salt formulation in soups by imitating industrial processing instead of home-made processing. Additionally, the effect of salt reduction on microbial safety of soups should be examined.

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References

Abdullah, N., Chin, N.L., Yusof, Y.A. and Talib, R.A., 2018. Modeling the Rheological Behavior of Thermosonic Extracted Guava, Pomelo, and Soursop Juice Concentrates at Different Concentration and Temperature Using a New Combination Model. Journal of Food Processing and Preservation, 42(2): e13517.

Adebowale, A.R. A. and Sanni, L.O., 2013. Effects of Solid Content and Temperature on Viscosity of Tapioca Meal. Journal of Food Science and Technology, 50(3): 573-578.

Ahmed, J., Ptaszek, P. and Basu, S., 2016. Advances in Food Rheology and its Applications. Woodhead Publishing.

Ainsworth, P. And Plunkett A., 2007. Reducing Salt in Snack Products, Reducing Salt in Foods: Practical strategies. Kilcast D, Angus F, editors. Cambridge, UK: Woodhead; 296–315.

Anonymous, 1985. Sensory analysis-Methodology-Flavour Profile Method. International Organization for Standardization: Geneva, Switzerland, 1-6.

Anonymous, 2000. Official Methods of Analysis, 17th Ed., Association of Official Analytical Chemists, Inc., Arlington, VA.

Anonymous, 2001. Voedingscentrum (The Netherlands Nutrition Centre), NEVO-tabel: Nederlands Voedingsstoffenbestand 2001/Stichting Nederlands Voedingsstoffenbestand (Dutch Food Composition Table: Dutch Food Composition Database 2001/Dutch Food Composition Database Foundation). Den Haag: Voedingscentrum.

Anonymous, 2007. WHO Document Production Services: Geneva, Switzerland; 2007. Reducing Salt Intake in Populations Report of a WHO Forum and Technical Meeting.

Anonymous, 2009. Centers for Disease Control and Prevention (CDC), Application of Lower Sodium İntake Recommendations to Adults: United States, 1999-2006. MMWR Morb Mortal Wkly Rep.; 58(11): 281-283.

Anonymous, 2010. CASH, Action on Salt. http://www.actiononsalt.org.uk/news/surveys/2010/soup/ (Accessed 16.03.2019).

Anonymous, 2012. The World's Best Bowl Food: Where to Find it and how to Make it.

Anonymous, 2018. Salt, https://www.betterhealth.vic.gov.au/health/healthyliving/salt (Accessed 11.03.2019).

Anonymous, 2019. https://www.ceptesok.com/arama/ezogelin#/ (Accessed 11.03.2019).

Augusto, P.E.D., Soares, B.M.C., Chiu, M.C. and Gonçalves, L.A.G., 2012. Modelling the Effect of Temperature on the Lipid Solid Fat Content. Food Research International, 45(1): 132–135.

Bachmanov, A.A., Bosak, N.P., Glendinning, J.I., Inoue, M., Li, X., Manita, S. and Beauchamp, G.K., 2016. Genetics of Amino Acid Taste and Appetite. Advances in Nutrition, 7(4): 806S-822S.

Björn, A., de La Monja, P.S., Karlsson, A., Ejlertsson, J. and Svensson, B.H., 2012. Rheological Characterization. In Biogas. InTech.

Carlucci, A. and Monteleone, E., 2001. Statistical Validation of Sensory Data: a Study on Wine. Journal of the Science of Food and Agriculture, 81: 751–758.

Cepanec, K., Vugrinec, S., Cvetkovic, T. and Ranilovic, J., 2017. Potassium Chloride-Based Salt Substitutes: A Critical Review with a Focus on the Patent Literature. Comprehensive Reviews in Food Science and Food Safety,16(5), 881-894.

Chopra, J.G., 1974. Enrichment and fortification of foods in Latin America. American Journal of Public Health, 64(1): 19-26.

Cordain, L., Eaton, S.B., Sebastian, A., Mann, N., Lindeberg, S., Watkins, B.A. and Brand-Miller, J., 2005. Origins and Evolution of the Western diet: Health İmplications for the 21st century. The American Journal of Clinical Nutrition, 81(2): 341-354.

Çelik, I., Isik, F. and Yilmaz, Y., 2010. Chemical, Rheological and Sensory Properties of Tarhana with wheat Bran as a Functional Constituent. Akademik Gida, 8(3): 11-17.

Desmond, E., 2007. Reducing Salt in Meat and Poultry Products. In Reducing salt in foods. Woodhead Publishing, 233-255.

Dewan, J., 2013. It's Soup Season, so Make it thick, http://www.chicagotribune.com/dining/recipes/sc-food-0222-prep-thick-soups-20130227-story.html (Accessed 02.01.2019).

Egresi, I., 2016. Alternative Tourism in Turkey: Role, Potential Development and Sustainability (Vol. 121). Springer.

Erbas, M., Certel, M. and Uslu, M.K., 2005. Microbiological and Chemical Properties of Tarhana During Fermentation and Storage as Wet-Sensorial Properties of Tarhana soup. Lebensmittel Wissenschaft und-Technologie, 38(4): 409-416.

Erdem, Y., Arıcı, M., Altun, B., Turgan, C., Sindel, S., Erbay, B., Derici, U., Karatan, O., Hasanoğlu, E. and Çağlar, S., 2010. The relationship between Hypertension and Salt İntake in Turkish population: SALTURK study. Blood Pressure, 19(5): 313-8.

Gao, X., Yu, T., Zhang, Z. H., Xu, J. C. and Fu, X. T., 2011. Rheological and Sensory Properties of Four Kinds of Jams. Journal of Stored Products and Postharvest Research, 2(11): 227-234.

Gonçalves, C., Monteiro, S., Padrão, P., Rocha, A., Abreu, S., Pinho, O. and Moreira, P., 2014. Salt Reduction in Vegetable Soup does not Affect Saltiness İntensity and Liking in the Elderly and Children. Food & Nutrition Research, 58(1): 24825.

Gratao, A.C.A., Silveira Jr, V. and Telis-Romero, J., 2007. Laminar Flow of Soursop Juice Through Concentric Annuli: Friction Factors and Rheology. Journal of Food Engineering, 78(4): 1343-1354.

Grigelmo, M.N., Ibarz, A.R. and Martin O.B., 1999. Rheology of Peach Dietary Suspensions. Journal of Food Engineering, 39: 91-99.

Hassan, B.H. and Hobani, A.I., 1998. Flow Properties of Roselle (Hibiscus sabdariffa L.) Extract. Journal of Food Engineering 35: 459–470.

Heikal, Y.A. and Chhinnan, M.S., 1990. Rheological Characterization of Tomato Puree at Different Temperatures Using Using two Types of Viscometers. In: Spiss WEL, Schubert H (eds) Engineering and Food: Physical Properties and Process Control. Elsevier Science, London, pp 133–142.

Holdsworth, S.D., 1971. Applicability of Rheological Models to the İnterpretation of Flow and Processing Behaviour of Fluid Food Products. Journal of Texture Studies, 2(4): 393-418.

Horita, C.N., Morgano, M.A., Celeghini, R.M.S. and Pollonio, M.A.R., 2011. Physico-chemical and Sensory Properties of Reduced-Fat Mortadella Prepared with Blends of Calcium, Magnesium and Potassium Chloride as Partial Substitutes for Sodium Chloride. Meat Science, 89(4): 426-433.

Hundal, J. and Takhar, P.S., 2009. Dynamic Viscoelastic Properties and Glass Transition Behavior of Corn Kernels. International Journal of Food Properties, 12(2): 295-307.

Ibanoglu, S. and Ibanoglu, E., 1998. Rheological Characterization of some Traditional Turkish Soups. Journal of Food Engineering, 35: 251–256.

Ichikawa, T. and Shimomura, M., 2007. Effects of Sodium Chloride and Other Salts on the Properties of Diluted Egg White Sols and Gels. Food Science and Technology Research, 13(2): 173-177.

Jacobson, M.F., Havas, S. and McCarter, R., 2013. Changes in Sodium Levels in Processed and Restaurant Foods, 2005 to 2011. JAMA Internal Medicine, 173(14): 1285-1291.

Juszczak, L., Witczak, M., Fortuna, T. and Solarz, B., 2010. Effect of Temperature and Soluble Solids Content on the Viscosity of Beetroot (Beta vulgaris) Juice Concentrate. International Journal of Food Properties, 13(6): 1364-1372.

Katsiari, M.C., Voutsinas, L.P., Alichanidis, E. and Roussis, I.G., 1997. Reduction of Sodium Content in Feta Cheese by Partial Substitution of NaCl by KCl. International Dairy Journal, 7: 465–472.

Kim, J.W., Samant, S.S., Seo, Y. and Seo, H.S. 2015. Variation in Saltiness Perception of Soup with Respect to Soup Serving Temperature and Consumer Dietary Habits. Appetite, 84: 73-78.

Koca, A.F., Koca, I., Anil, M., Hasbay, I. and Yilmaz, V.A., 2015. Physical, Rheological and Sensory Properties of Tarhana Prepared with Two Wild Edible Plants (Trachystemon orientalis (L.) G. Don) and (Portulaca oleracea L.). Journal of Food Processing Technology, 6: 5.

Kremer, S., Mojet, J. and Shimojo, R., 2009. Salt Reduction in Foods Using Naturally Brewed Soy Sauce. Journal of Food Science, 74: 6.

Leong, J., Kasamatsu, C., Ong, E., Hoi, J. T. and Loong, M.N., 2016. A Study on Sensory Properties of Sodium Reduction and Replacement in Asian Food Using Difference-from–Control Test. Food science & nutrition, 4(3): 469-478.

Maskan M. and Göğüş, F., 2000. Effect of Sugar on the Rheological Properties of Sunflower Oil-Water Emulsions. Journal of Food Engineering, 43:173-177.

Mitchell, M., Brunton, N.P. and Wilkinson, M.G., 2011. Impact of Salt Reduction on the Instrumental and sensory flavor profile of vegetable soup. Food Research International, 44: 1036-1043.

Mueller, E., Koehler, P. and Scherf, K.A., 2016. Applicability of Salt Reduction Strategies in pizza Crust. Food Chemistry, 192: 1116-1123.

Nayik, G.A., Dar, B.N. and Nanda, V., 2018. Rheological Behavior of High Altitude Indian Honey Varieties as Affected by Temperature. Journal of the Saudi Society of Agricultural Sciences, 17(3): 323-329.

Niththiya, N.V., Subajini, M. and Srivijeindran, S., 2014. Formulation of Instant Soup Mix Powder Using Uncooked Palmyrah (Borassus flabellifer) Tuber Flour and Locally Available Vegetables. Jaffna University International Research Conference.

Ophardt, C.E., 2003. Characteristics and Properties of Amino Acids, http://chemistry.elmhurst.edu/vchembook/561aminostructure.html (Accessed 03.01.2019).

Pham, K.V., 2013. Go with the Flow: The Effect of Solute Concentration on Viscosity, http://cssf.usc.edu/History/2013/Projects/S0321.pdf (Accessed 03.03.2019).

Rao, M.A. and Anatheswaran, R.C. 1982. Rheology of Fluids in Food Processing. Food Technology, 36: 116- 126.

Roininen, K., Lähteenmäki, L. and Tuorilla, H., 1996. Effect of Umami Taste on Pleasantness of Low-Salt Soups during Repeated Testing. Physiology & Behavior, 60(3): 953-958.

Sahin, S. and Sumnu, S.G., 2006. Rheological Properties of Foods. In Physical Properties of Foods (pp. 39-105). Springer, New York, NY.

Sengul, S., Erdem, Y., Akpolat, T., Derici, U., Sindel, S., Karatan, O. and Erturk, S., 2013. Controlling Hypertension in Turkey: not a Hopeless Dream. Kidney International Supplements, 3(4): 326-331.

Sinopoli, D.A. and Lawless, H.T., 2012. Taste Properties of Potassium Chloride Alone and in Mixtures with Sodium Chloride Using a Check-All-That-Apply Method. Journal of Food Science, 77(9).

Sopade, P.A. and Filibus, T.E., 1995. The İnfluence of Solid and Sugar Contents on Rheological Characteristics of Akamu, a Semi-Liquid Maize Food. Journal of Food Engineering, 24: 197-211.

Sopade, P.A., Kassum, A.L., and Adamu, D.J., 1993. Rheological Characterization of some Nigerian Traditional Soups. International Journal of Food Science & Technology, 28(6): 647-653.

Steffe, J.F., 1996. Rheological Methods in Food Processing Engineering (2nd ed.). Michigan, USA: Freeman Press.

Waimaleongora-Ek, P., 2006. Sensory Characteristics of Salt Substitute Containing L-arginine. (Unpublished master's thesis). Thammasat University, Tayland.

Webster, J.L., Dunford, E.K., Hawkes, C. and Neal, B.C., 2011. Salt Reduction İnitiatives Around the World. Journal of Hypertension, 29(6): 1043-1050.

Yang, Q., Liu, T., Kuklina, E.V., Flanders, W.D., Hong, Y., Gillespie, C. and Hu, F.B., 2011. Sodium and Potassium İntake and Mortality Among US adults: Prospective Data from the Third National Health and Nutrition Examination Survey. Archives of internal medicine, 171(13): 1183-1191.

Yilmaz, M.T., Sert, D. and Demir, M.K., 2010. Rheological Properties of Tarhana Soup Enriched with whey Concentrate as a Function of Concentration and Temperature. Journal of Texture Studies, 41(6): 863-879.